REPORT OF TEST

NIST Test # 39073S - Spectral Responsivity

for

Hamamatsu S2281 Silicon Photodiode, Cxxx

Submitted by:

Any Company
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(See your Purchase Order No. XXXX-XX, dated January 1, 1993)

1. Description of Test Material

The test photodiode, labeled Cxxx, is a Hamamatsu S2281 silicon photodiode in an anodized aluminum mount with a removable precision aperture and a BNC connector. The active area of the photodiode is ≈ 1 cm^2.

2. Description of Test

The test photodiode was compared to two silicon photodiode working standards, H6xx and H6xx, using the NIST visible to near Infrared (Vis/NIR) monochromator-based comparator facility [1] from 350 nm to 1100 nm in 5 nm increments. The spectral comparisons between the test photodiode and working standard photodiodes were performed using a double monochromator and a quartz-halogen lamp as the tunable monochromatic source.

The circular exit aperture of the Vis/NIR monochromator was imaged ($\approx f/9$) on the test photodiode, resulting in a beam diameter at the photodiode of 1.1 mm. The beam was centered on, and underfilled, the aperture.

The wavelength scale of the monochromator was calibrated with several laser and emission lines and is accurate to ± 0.1 nm over the entire spectral range. The bandpass of the monochromator was 4 nm. The short-circuit photocurrent from the test photodiode and each working standard photodiode was measured with a calibrated transimpedance amplifier. The test photodiode and each working standard photodiode were measured with zero bias voltage. Beam power fluctuations were monitored with a beamsplitter and silicon photodiode. The absolute spectral responsivity scale is based on a high accuracy cryogenic radiometer with a relative expanded uncertainty ($k = 2$) to absolute (SI) units of 0.2 %.

The spatial uniformity of the responsivity across the test photodiode photosensitive area was measured at 500 nm using the described comparator facility. The uniformity was measured in 0.5 mm increments using a 1.1 mm diameter beam.

Laboratory Environment:
Temperature: 23.x °C ± 0.3 °C

Test Date: December 24, 1997
NIST Test No.: 844/xxxxxx-97/2

3. Results of Test

The absolute spectral responsivity in amperes per watt of the test photodiode is presented as a function of wavelength in table 1 and is plotted in figure 1. The relative expanded uncertainties in the NIST absolute scale are described in Ref. [1]. The relative expanded uncertainty (k = 2) presented as a function of wavelength for this measurement is stated relative to absolute (SI) units and is listed in table 1 and plotted in figure 1.

Table 2 lists the dimensions of the precision aperture furnished with the test photodiode. The reported aperture area and distance from the aperture plate to the photodiode surface do not enter into the responsivity measurement results because the optical beam underfills the aperture. The uncertainty values reported with the aperture dimensions are expanded uncertainties.

Figure 2a is a plot of the uniformity of the test photodiode, showing 0.2 % contours at 500 nm of the deviations from the responsivity at the photodiode center. Figure 2b is a 3-dimensional plot showing the responsivity relative to the center of the photodiode. Errors larger than the stated uncertainties can occur if the irradiation geometry is significantly different from the test conditions described in section 2.

Figure 1
Absolute Spectral Responsivity of Silicon Photodiode Cxxx

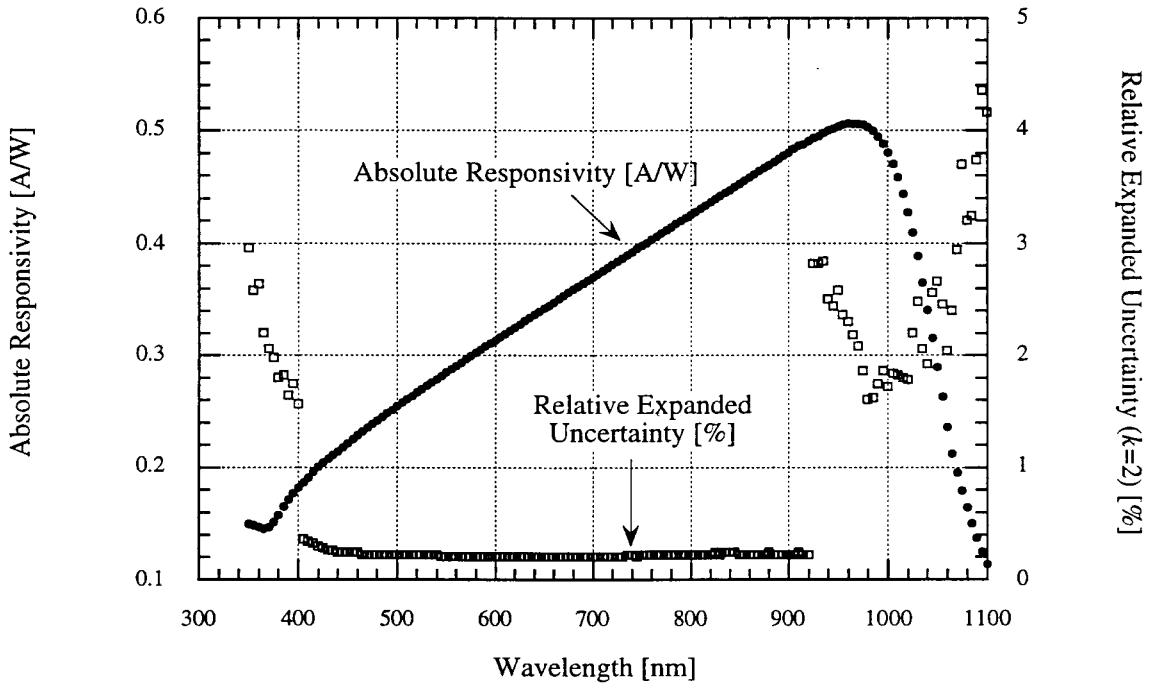

Table 1
Absolute Spectral Responsivity of Silicon Photodiode Cxxx

Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty (k = 2) [%]	Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty (k = 2) [%]
350	1.50E-1	3.0	550	2.848E-1	0.20
355	1.49E-1	2.6	555	2.877E-1	0.20
360	1.47E-1	2.6	560	2.906E-1	0.20
365	1.45E-1	2.2	565	2.935E-1	0.20
370	1.47E-1	2.1	570	2.965E-1	0.20
375	1.51E-1	2.0	575	2.994E-1	0.20
380	1.58E-1	1.8	580	3.023E-1	0.20
385	1.65E-1	1.8	585	3.052E-1	0.20
390	1.71E-1	1.6	590	3.081E-1	0.20
395	1.77E-1	1.7	595	3.109E-1	0.20
400	1.82E-1	1.6	600	3.138E-1	0.20
405	1.860E-1	0.36	605	3.166E-1	0.20
410	1.909E-1	0.34	610	3.195E-1	0.20
415	1.959E-1	0.32	615	3.223E-1	0.20
420	2.008E-1	0.30	620	3.252E-1	0.20
425	2.041E-1	0.28	625	3.280E-1	0.20
430	2.079E-1	0.26	630	3.308E-1	0.20
435	2.113E-1	0.26	635	3.337E-1	0.20
440	2.141E-1	0.24	640	3.365E-1	0.20
445	2.178E-1	0.24	645	3.393E-1	0.20
450	2.214E-1	0.24	650	3.421E-1	0.20
455	2.250E-1	0.24	655	3.449E-1	0.20
460	2.284E-1	0.24	660	3.477E-1	0.20
465	2.319E-1	0.22	665	3.505E-1	0.20
470	2.352E-1	0.22	670	3.534E-1	0.20
475	2.385E-1	0.22	675	3.562E-1	0.20
480	2.418E-1	0.22	680	3.589E-1	0.20
485	2.450E-1	0.22	685	3.617E-1	0.20
490	2.482E-1	0.22	690	3.645E-1	0.20
495	2.513E-1	0.22	695	3.673E-1	0.20
500	2.545E-1	0.22	700	3.701E-1	0.20
505	2.576E-1	0.22	705	3.729E-1	0.20
510	2.607E-1	0.22	710	3.756E-1	0.20
515	2.638E-1	0.22	715	3.784E-1	0.20
520	2.668E-1	0.22	720	3.812E-1	0.20
525	2.699E-1	0.22	725	3.840E-1	0.20
530	2.729E-1	0.22	730	3.868E-1	0.20
535	2.759E-1	0.22	735	3.896E-1	0.22
540	2.788E-1	0.22	740	3.923E-1	0.22
545	2.818E-1	0.20	745	3.951E-1	0.20

Table 1 (cont.)
Absolute Spectral Responsivity of Silicon Photodiode Cxxx

Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty (k = 2) [%]	Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty (k = 2) [%]
750	3.978E-1	0.22	925	4.93E-1	2.8
755	4.007E-1	0.22	930	4.95E-1	2.8
760	4.034E-1	0.22	935	4.97E-1	2.8
765	4.061E-1	0.22	940	5.00E-1	2.5
770	4.088E-1	0.22	945	5.02E-1	2.4
775	4.116E-1	0.22	950	5.03E-1	2.6
780	4.144E-1	0.22	955	5.04E-1	2.4
785	4.171E-1	0.22	960	5.06E-1	2.3
790	4.199E-1	0.22	965	5.05E-1	2.2
795	4.227E-1	0.22	970	5.05E-1	2.1
800	4.254E-1	0.22	975	5.04E-1	1.9
805	4.282E-1	0.22	980	5.02E-1	1.6
810	4.309E-1	0.22	985	4.98E-1	1.6
815	4.336E-1	0.22	990	4.93E-1	1.7
820	4.364E-1	0.22	995	4.87E-1	1.9
825	4.391E-1	0.24	1000	4.79E-1	1.7
830	4.418E-1	0.22	1005	4.69E-1	1.8
835	4.446E-1	0.24	1010	4.57E-1	1.8
840	4.473E-1	0.24	1015	4.42E-1	1.8
845	4.502E-1	0.24	1020	4.26E-1	1.8
850	4.528E-1	0.22	1025	4.08E-1	2.2
855	4.556E-1	0.22	1030	3.87E-1	2.5
860	4.584E-1	0.22	1035	3.63E-1	2.1
865	4.610E-1	0.22	1040	3.38E-1	1.9
870	4.638E-1	0.22	1045	3.13E-1	2.6
875	4.665E-1	0.22	1050	2.86E-1	2.7
880	4.693E-1	0.24	1055	2.60E-1	2.5
885	4.720E-1	0.22	1060	2.33E-1	2.0
890	4.747E-1	0.22	1065	2.09E-1	2.4
895	4.774E-1	0.22	1070	1.91E-1	2.9
900	4.802E-1	0.22	1075	1.75E-1	3.7
905	4.833E-1	0.22	1080	1.60E-1	3.2
910	4.861E-1	0.24	1085	1.46E-1	3.2
915	4.876E-1	0.22	1090	1.33E-1	3.7
920	4.902E-1	0.22	1095	1.20E-1	4.4
			1100	1.09E-1	4.2

Figure 2a
Responsivity Uniformity of Silicon Photodiode Cxxx
0.2 % contours at 500 nm; 1.1 mm resolution; 0.5 mm/Step

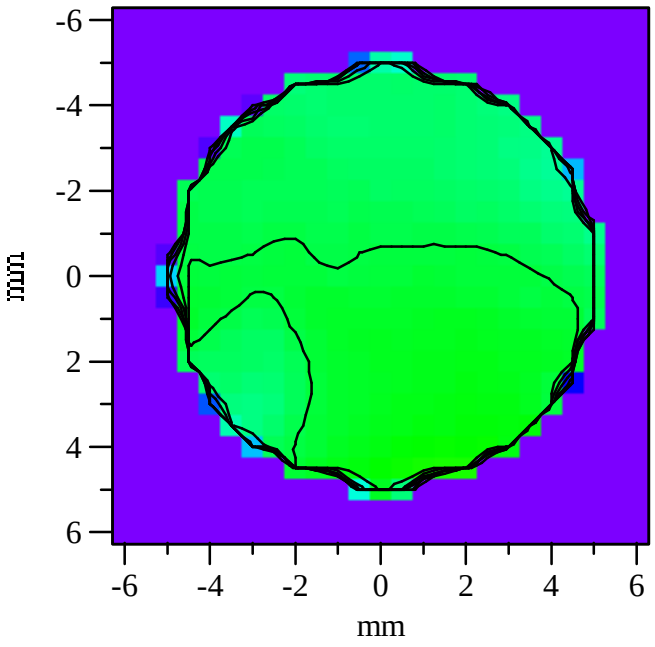

Figure 2b
Surface Plot of Responsivity Relative to
Center of Photodiode for Silicon Photodiode Cxxx
at 500 nm; 0.5 mm/Step

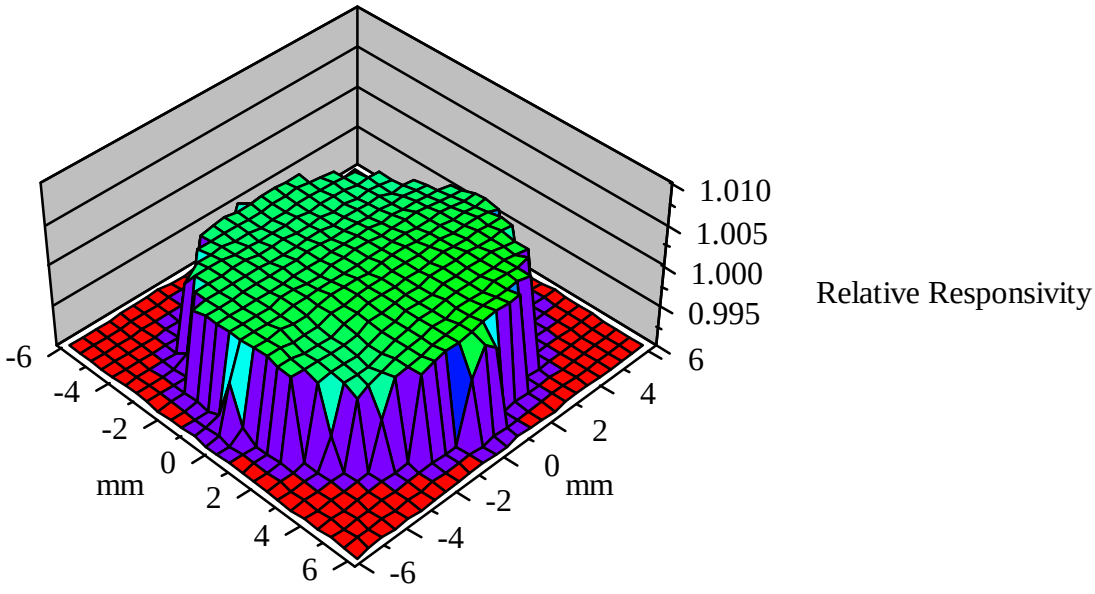

Table 2
Aperture Dimensions

Area:	0.5xxx $\pm$ 0.0005 cm^2
Distance from aperture plane to photodiode surface:	5.0 $\pm$ 0.5 mm

4. General Information

A documentation appendix includes operating instructions for the test photodiode. The laboratory temperature is reported for information only. It is not intended that this data be used for corrections to the spectral responsivity data in this report. This report shall not be reproduced, except in full, without the written approval of NIST.

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Reference:

[1] T. C. Larason, S. S. Bruce, and A. C. Parr, NIST Measurement Services: Spectroradiometric Detector Measurements: Part I - Ultraviolet Detectors and Part II - Visible to Near-Infrared Detectors, Natl. Inst. Stand. Technol., Spec. Publ. 250-41 (1998).

APPENDIX:

OPERATING INSTRUCTIONS FOR NIST PHOTODIODE

The NIST characterized photodiode consists of a silicon photodiode with a removable precision aperture, a quartz window, and a BNC connector.

A. The photodiode should be rigidly mounted on a dual-axis tilt mount such that the photodiode can be tilted about two orthogonal axis. The photodiode should be adjusted to be perpendicular to the incident radiation.

B. The incident beam of radiation should be smaller than the aperture, and should be centered in the photodiode aperture.

C. The photodiode should be connected with a BNC cable to an electrometer grade amplifier (transimpedance amplifier) which measures the current from the photodiode.

D. The inside edge of the precision aperture is extremely delicate and should not be touched with fingers or any other object.

E. The diode window can be cleaned with lens tissue and spectral grade solvent. The precision aperture should be removed before cleaning the photodiode window.